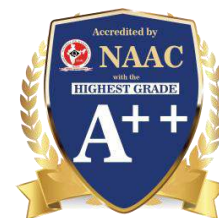
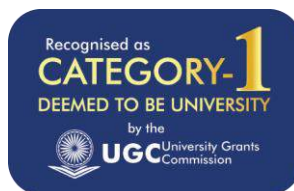




**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Deemed to be University Estd. u/s 3 of UGC Act, 1956)



## Ph.D. Entrance Examination Syllabus

### Table of Content

S. No.	Content	Page No.
<b>Part – A (Common to all Departments)</b>		
1	Research Methodology	1
<b>Part – B (Department Specific)</b>		
2	Civil Engineering	3
3	Common to Aeronautical Engineering and Mechanical Engineering	6
4	Common to Computer Science and Engineering & Information Technology	9
5	Common to EEE and ECE	11
6	Biotechnology	14
7	Biomedical Engineering	16
8	Management	18
9	Law	20
10	Chemistry	21
11	English	24
12	Mathematics	25
13	Physics	27

# **1. RESEARCH METHODOLOGY**

## **UNIT I –RESEARCH FORMULATION AND DESIGN**

Motivation and objectives – Research methods *vs.* Methodology. Types of research – Descriptive *vs.* Analytical, Applied *vs.* Fundamental, Quantitative *vs.* Qualitative, Conceptual *vs.* Empirical, concept of applied and basic research process, criteria of good research.

Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, literature review-primary and secondary sources, reviews, monograph, patents, research databases, web as a source, searching the web, critical literature review, identifying gap areas from literature and research database, development of working hypothesis.

## **UNIT II – DATA COLLECTION AND ANALYSIS**

Accepts of method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools, data analysis with statically package (Sigma STAT,SPSS for student t-test, ANOVA, etc.), hypothesis testing.

## **UNIT III – SOFT COMPUTING**

Computer and its role in research, Use of statistical software SPSS, GRETL etc in research. Introduction to evolutionary algorithms - Fundamentals of Genetic algorithms, Simulated Annealing, Neural Network based optimization, Optimization of fuzzy systems.

## **UNIT IV –RESEARCH ETHICS, IPR AND SCHOLARY PUBLISHING**

Ethics-ethical issues, ethical committees (human & animal); IPR- intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); scholarly publishing- IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability.

## **UNIT V –INTERPRETATION AND REPORT WRITING**

Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions.

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3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.

## Additional reading

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
3. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
4. Day, R.A., 1992. How to Write and Publish a Scientific Paper, Cambridge University Press.
5. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
6. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
7. Satarkar, S.V., 2000. Intellectual property rights and Copy right. Ess Ess Publications.

## 2. CIVIL ENGINEERING

**Linear Algebra:** Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

**Calculus:** Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

**Differential equations:** First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

**Complex variables:** Analytic functions, Cauchy's integral theorem, Taylor and Laurent series.

**Probability and Statistics:** Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions.

**Numerical Methods:** Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

### STRUCTURAL ENGINEERING

**Mechanics:** Bending moment and shear force in statically determinate beams. Simple stress and strain relationship: Stress and strain in two dimensions, principal stresses, stress transformation, Mohr's circle. Simple bending theory, flexural and shear stresses, unsymmetrical bending, shear centre. Thin walled pressure vessels, uniform torsion, buckling of column, combined and direct bending stresses.

**Structural Analysis:** Analysis of statically determinate trusses, arches, beams, cables and frames, displacements in statically determinate structures and analysis of statically indeterminate structures by force/ energy methods, analysis by displacement methods (slope deflection and moment distribution methods), influence lines for determinate and indeterminate structures. Basic concepts of matrix methods of structural analysis.

**Concrete Structures:** Concrete Technology- properties of concrete, basics of mix design. Concrete design- basic working stress and limit state design concepts, analysis of ultimate load capacity and design of members subjected to flexure, shear, compression and torsion by limit state methods. Basic elements of pre-stressed concrete, analysis of beam sections at transfer and service loads.

**Steel Structures:** Analysis and design of tension and compression members, beams and beam- columns, column bases. Connections- simple and eccentric, beam–column connections, plate girders and trusses. Plastic analysis of beams and frames.

### **GEOTECHNICAL ENGINEERING**

**Soil Mechanics:** Origin of soils, soil classification, three-phase system, fundamental definitions, relationship and interrelationships, permeability & seepage, effective stress principle, consolidation, compaction, shear strength. Liquefaction of soils.

**Foundation Engineering:** Sub-surface investigations- scope, drilling bore holes, sampling, penetration tests, plate load test. Earth pressure theories, effect of water table, layered soils. Stability of slopes- infinite slopes, finite slopes. Foundation types- foundation design requirements. Shallow foundations- bearing capacity, effect of shape, water table and other factors, stress distribution, settlement analysis in sands & clays. Deep foundations–pile types, dynamic & static formulae, load capacity of piles in sands & clays, negative skin friction.

### **WATER RESOURCES ENGINEERING**

**Fluid Mechanics and Hydraulics:** Properties of fluids, principle of conservation of mass, momentum, energy and corresponding equations, potential flow, applications of momentum and Bernoulli's equation, laminar and turbulent flow, flow in pipes, pipe networks. Concept of boundary layer and its growth. Uniform flow, critical flow and gradually varied flow in channels, specific energy concept, hydraulic jump. Forces on immersed bodies, flow measurements in channels, tanks and pipes. Dimensional analysis and hydraulic modeling. Kinematics of flow, velocity triangles and specific speed of pumps and turbines.

**Hydrology:** Hydrologic cycle, rainfall, evaporation, infiltration, stage discharge relationships, unit hydrographs, flood estimation, reservoir capacity, reservoir and channel routing. Well hydraulics.

**Irrigation:** Duty, delta, estimation of evapo-transpiration. Crop water requirements. Design of: lined and unlined canals, waterways, head works, gravity dams and spillways. Design of weirs on permeable foundation. Types of irrigation system, irrigation methods. Water logging and drainage, sodic soils.

### **ENVIRONMENTAL ENGINEERING**

**Water requirements:** Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quantity and characteristics of

wastewater. Primary, secondary and tertiary treatment of wastewater, sludge disposal, effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment Unit operations and unit processes of domestic wastewater, sludge disposal.

**Air Pollution:** Types of pollutants, their sources and impacts, air pollution, air pollution control, air quality standards and limits, meteorology

**Municipal Solid Wastes:** Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

**Noise Pollution:** Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

### **TRANSPORTATIONENGINEERING**

**Highway Planning:** Geometric design of highways, testing and specifications of paving materials, design of flexible and rigid pavements.

**Traffic Engineering:** Traffic characteristics, theory of traffic flow, intersection design, traffic signs and signal design, highway capacity.

### **SURVEYING**

Importance of surveying, principles and classifications, mapping concepts, coordinate system, map projections, measurements of distance and directions, leveling, theodolite traversing, plane table surveying, errors and adjustments, curves.

### 3. COMMON TO AERONAUTICAL ENGINEERING AND MECHANICAL ENGINEERING

#### Section 1: Engineering Mathematics

**Linear Algebra:** Matrix algebra, systems of linear equations, eigenvalues and eigenvectors.

**Calculus:** Functions of single variable, limit, continuity and differentiability, mean value theorems, indeterminate forms; evaluation of definite and improper integrals; double and triple integrals; partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, Fourier series; gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems.

**Differential equations:** First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems; Laplace transforms; solutions of heat, wave and Laplace's equations.

**Complex variables:** Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and integral formula; Taylor and Laurent series.

**Probability and Statistics:** Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions.

**Numerical Methods:** Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

#### Section 2: Applied Mechanics and Design

**Engineering Mechanics:** Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations, collisions.

**Mechanics of Materials:** Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods;

thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

**Theory of Machines:** Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

**Vibrations:** Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts, Vehicle Dynamics

**Machine Design:** Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs, Automatic transmission.

### **Section 3: Fluid Mechanics and Thermal Sciences**

**Fluid Mechanics:** Fluid properties; fluid statics, manometry, buoyancy, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings. Flow separation, introduction to turbulence, transition, structure of a turbulent boundary layer.

**Heat-Transfer:** Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis.

**Thermodynamics:** Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.



**Applications:** Power Engineering: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. I.C. Engines: Air-standard Otto, Diesel and dual cycles. Refrigeration and air-conditioning: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. Turbomachinery: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines. Thermodynamics of Aircraft Gas Turbine engines.

**Alternative fuels:** Estimate of petroleum reserve, properties of alternate fuels, CNG, LPG, Alcohol, Vegetable oil, Bio-gas, ethanol and hydrogen - Production methods, storage and handling, safety aspects.

#### **Section 4: Materials, Manufacturing and Industrial Engineering**

**Engineering Materials:** Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials, powder metallurgy, composite materials.

**Casting, Forming and Joining Processes:** Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

**Machining and Machine Tool Operations:** Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, design of jigs and fixtures.

**Metrology and Inspection:** Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.

**Computer Integrated Manufacturing:** Basic concepts of CAD/CAM and their integration tools.

**Production Planning and Control:** Forecasting models, aggregate production planning, scheduling, materials requirement planning, Inventory Control, Operations Research.

## 4. COMMON TO COMPUTER SCIENCE AND ENGINEERING & INFORMATION TECHNOLOGY

### *ENGINEERING MATHEMATICS*

**Mathematical Logic:** Propositional Logic; First Order Logic.

**Probability:** Conditional Probability; Mean, Median, Mode and Standard Deviation; Random Variables; Distributions; uniform, normal, exponential, Poisson, Binomial.

**Set Theory & Algebra:** Sets; Relations; Functions; Groups; Partial Orders; Lattice; Boolean Algebra.

**Combinatorics:** Permutations; Combinations; Counting; Summation; generating functions; recurrence relations; asymptotics.

**Graph Theory:** Connectivity; spanning trees; Cut vertices & edges; covering; matching; independent sets; Colouring; Planarity; Isomorphism.

**Linear Algebra:** Algebra of matrices, determinants, systems of linear equations, Eigen values and Eigen vectors.

**Numerical Methods:** LU decomposition for systems of linear equations; numerical solutions of non-linear algebraic equations by Secant, Bisection and Newton-Raphson Methods; Numerical integration by trapezoidal and Simpson's rules.

**Calculus:** Limit, Continuity & differentiability, Mean value Theorems, Theorems of integral calculus, evaluation of definite & improper integrals, Partial derivatives, Total derivatives, maxima & minima.

### *COMPUTER SCIENCE AND INFORMATION TECHNOLOGY*

**Computer Organization and Architecture:** Machine instructions and addressing modes, ALU and data-path, CPU control design, Memory interface, I/O interface (Interrupt and DMA mode), Instruction pipelining, Cache and main memory, Secondary storage.

**Programming and Data Structures:** Programming in C; Functions, Recursion, Parameter passing, Scope, Binding; Abstract data types, Arrays, Stacks, Queues, Linked Lists, Trees, Binary search trees, Binary heaps.

**Algorithms:** Analysis, Asymptotic notation, Notions of space and time complexity, Worst and average case analysis; Design: Greedy approach, Dynamic programming, Divide-and-conquer; Tree and graph traversals, Connected components, Spanning trees, Shortest paths; Hashing, Sorting, Searching. Asymptotic analysis (best, worst, average cases) of time and space, upper and lower bounds, Basic concepts of complexity classes – P, NP, NP-hard, NP-complete.

**Theory of Computation:** Regular languages and finite automata, Context free languages and Push-down automata, Recursively enumerable sets and Turing machines, Undecidability.

**Compiler Design:** Lexical analysis, Parsing, Syntax directed translation, Runtime environments, Intermediate and target code generation, Basics of code optimization.

**Operating System:** Processes, Threads, Inter-process communication, Concurrency, Synchronization, Deadlock, CPU scheduling, Memory management and virtual memory, File systems, I/O systems, Protection and security.

**Databases:** ER-model, Relational model (relational algebra, tuple calculus), Database design (integrity constraints, normal forms), Query languages (SQL), File structures (sequential files, indexing, B and B+ trees), Transactions and concurrency control.

**Information Systems and Software Engineering:** information gathering, requirement and feasibility analysis, data flow diagrams, process specifications, input/output design, process life cycle, planning and managing the project, design, coding, testing, implementation, maintenance.

**Computer Networks:** ISO/OSI stack, LAN technologies (Ethernet, Token ring), Flow and error control techniques, Routing algorithms, Congestion control, TCP/UDP and sockets, IP(v4), Application layer protocols (icmp, dns, smtp, pop, ftp, http); Basic concepts of hubs, switches, gateways, and routers. Network security – basic concepts of public key and private key cryptography, digital signature, firewalls.

**Web technologies:** HTML, XML, basic concepts of client-server computing.

## 5. COMMON TO EEE AND ECE

### Ph.D Entrance Exam Syllabus

#### Section 1: Engineering Mathematics

**Linear Algebra:** Vector space, basis, linear dependence and independence, matrix algebra, eigen values and eigen vectors, rank, solution of linear equations – existence and uniqueness.

**Calculus:** Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.

**Differential Equations:** First order equations (linear and nonlinear), higher order linear differential equations, Cauchy's and Euler's equations, methods of solution using variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.

**Vector Analysis:** Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stoke's theorems.

**Complex Analysis:** Analytic functions, Cauchy's integral theorem, Cauchy's integral formula; Taylor's and Laurent's series, residue theorem.

**Numerical Methods:** Solution of nonlinear equations, single and multi-step methods for differential equations, convergence criteria.

**Probability and Statistics:** Mean, median, mode and standard deviation; combinatorial probability, probability distribution functions - binomial, Poisson, exponential and normal; Joint and conditional probability; Correlation and regression analysis.

#### Section 2: Electric Circuits

Network graph, KCL, KVL, Node and Mesh analysis, Transient response of dc and ac networks, Sinusoidal steady-state analysis, Resonance, Passive filters, Ideal current and voltage sources, Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum power transfer theorem, Two-port networks, Three phase circuits, Power and power factor in ac circuits.

#### Section 3: Electromagnetic Fields

Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Biot-Savart's law, Ampere's law, Curl, Faraday's law, Lorentz force, Inductance, Maxwell's equations, Self and mutual inductance of simple configurations.

#### **Section 4: Signals and Systems**

Representation of continuous and discrete-time signals, Shifting and scaling operations, Linear Time Invariant and Causal systems, Fourier series representation of continuous periodic signals, Sampling theorem, Applications of Fourier Transform, Laplace Transform and z-Transform.

Continuous-time signals: Fourier series and Fourier transform representations, sampling theorem and applications; Discrete-time signals: discrete-time Fourier transform (DTFT), DFT, FFT, Z-transform, interpolation of discrete-time signals; LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay, digital filter design techniques.

#### **Section 5: Linear Control Systems**

Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; Transient and steady-state analysis of LTI systems; Time Response & Frequency response Analysis; Routh-Hurwitz and Nyquist stability criteria; Bode and root-locus plots; Lag, lead and lag-lead compensation; State variable model and solution of state equation of LTI systems

#### **Section 6: Measurements & Instrumentation**

Bridges and Potentiometers, Measurement of voltage, current, power, energy and power factor; Instrument transformers, Digital voltmeters and multimeters, Phase, Time and Frequency measurement; Oscilloscopes, Error analysis, Megger, Bridges, Q meter.

Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (differential pressure, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, holometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement.

#### **Section 7: Micro Processor & Micro Controller**

Microprocessor 8086 architecture - Addressing modes - Instruction set and assembler directives - Assembly language programming - Modular Programming - Linking and Relocation - Stacks - Procedures - Macros - Interrupts and interrupt service routines - Byte and String Manipulation, Architecture of 8051 - Special Function Registers(SFRs) - I/O Pins Ports and Circuits - Instruction set - Addressing modes - Assembly language programming.



### **Section 8: Electrical Machines**

Construction of DC machines – Theory of operation of DC generators – Characteristics of DC generators- Operating principle of DC motors – Types of DC motors and their characteristics – Speed control of DC motors- Applications. Single phase and Three Phase Transformers - construction and principle of operation – EMF equation of transformer-Transformer no-load phasor diagram – Equivalent circuit of transformer – Regulation and efficiency of transformer, Parallel operation of Transformers.


### **Section 9: Electronic Devices**

Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; Generation and recombination of carriers; Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell; Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography and twin-tub CMOS process.

### **Section 10: Analog & Digital Electronics**

AND, OR, NOT, NAND, NOR, Exclusive-OR and Exclusive-NOR Implementations of Logic Functions using gates, comparators, multi-vibrators, sequential circuits, flip-flops, shift registers, timers and counters; sample-and-hold circuit, multiplexer, analog-to-digital (successive approximation, integrating, flash and sigma-delta) and digital-to-analog converters (weighted R, R-2R ladder and current steering logic). Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time)

Simple diode circuits: clipping, clamping and rectifiers; Single-stage BJT and MOSFET amplifiers: biasing, bias stability, mid-frequency small signal analysis and frequency response; BJT and MOSFET amplifiers: multi-stage, differential, feedback, power and operational; Simple op-amp circuits; Active filters; Sinusoidal oscillators: criterion for oscillation, single-transistor and op-amp configurations; Function generators, wave-shaping circuits and 555 timers; Voltage reference circuits; Power supplies: ripple removal and regulation.

  
28/9/2015

## 6. BIOTECHNOLOGY

**Biochemistry, Microbiology & Cell Biology:** Structure and functions of Biomolecules; Basic concepts and designs of metabolism (carbohydrates, lipids, amino acids and nucleic acids) photosynthesis, respiration and electron transport chain Enzymes- classification, kinetics and mechanism of action. Microbial classification and diversity (bacterial, algal and fungal); Methods in microbiology; Microbial growth and nutrition; Aerobic and anaerobic respiration Viruses- structure and classification; Nitrogen fixation; Microbial diseases and host-pathogen interaction. Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control; Cell-Cell communication, Cell signalling and signal transduction.

**Molecular Biology, Genetics and Genetic Engineering, Plant & Animal Biotechnology :** Molecular structure of genes and chromosomes; Nucleic acid replication, transcription, translation and their regulatory mechanisms in prokaryotes and eukaryotes; Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extra chromosomal inheritance; Microbial genetics (plasmids, transformation, transduction, conjugation); DNA damage and repair; Molecular basis of genetic diseases. Restriction and modification enzymes; Vectors; plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, yeast artificial chromosome; mammalian and plant expression vectors; cDNA and genomic DNA library; Gene isolation, cloning and expression ; Transposons and gene targeting; DNA labeling; DNA sequencing; Polymerase chain reactions; DNA fingerprinting; Southern and northern blotting; In-situ hybridization; RAPD, RFLP; Site-directed mutagenesis; Gene transfer technologies; Gene therapy. Totipotency; Regeneration of plants; Plant growth regulators and elicitors; Tissue culture and Cell suspension culture system: methodology, transgenic plants; Plant products of industrial importance. Animal cell culture, Hybridoma technology; Stem cell technology; Animal cloning; Transgenic animals.

**Immunology :** History of Immunology; Innate, humoral and cell mediated immunity; Antigen; Antibody structure and function; Molecular basis of antibody diversity; Synthesis of antibody and secretion; Antigen-antibody reaction; Complement; Primary and secondary lymphoid organ; B and T cells and macrophages; Major histocompatibility complex (MHC); Antigen processing and presentation; Polyclonal and monoclonal antibody; Regulation of immune response; Immune tolerance; Hypersensitivity; Autoimmunity; Graft versus host reaction.

**Chemical and Bioprocess engineering:** Principle of reactor design, ideal and non-ideal multiphase bioreactors, mass and heat transfer; Aeration and agitation; Media formulation and optimization; Kinetics of microbial growth, substrate utilization and product formation; Sterilization of air and media; Batch, fed-batch and continuous processes; Various types of microbial and enzyme reactors; Instrumentation control and optimization; Unit operations; Process scale-up, economics and feasibility analysis. Bioprocess design and development from lab to industrial scale; Microbial, animal and plant cell culture platforms; Production of biomass and primary/secondary metabolites; Biofuels, Bioplastics, industrial enzymes, antibiotics; Large scale production and purification of recombinant proteins; Industrial application of chromatographic and membrane based Bioseparation methods; Immobilization of biocatalysts (enzymes and cells) for bioconversion processes; Bioremediation-Aerobic and anaerobic processes for stabilization of solid / liquid wastes

**Nanobiotechnology and Emergent areas:** Various types of nanostructured materials with usage and potential within Biotechnology. Biomaterials and biomolecules as bases for inorganic structures. Applications within bioseparation, diagnostics, the drug delivery and bioimplants. Formulation/administration of drugs. Molecular prints of biomolecules. Production and applications of inorganic replicas of biological materials. Applications of Nanostructured and Multi-functional nanomaterials, Metabolic engineering principles and methods.



## **7. BIOMEDICAL ENGINEERING**

### **UNIT I Anatomy and Human Physiology**

Basics of cell, types of tissues and organ systems; Homeostasis; Basics of organ systems musculoskeletal, respiratory, circulatory, excretory, endocrine, nervous, gastrointestinal, and reproductive.

### **Unit II Signal & Systems**

Continuous and Discrete Signal and Systems - Periodic, aperiodic and impulse signals; Sampling theorem; Laplace and Fourier transforms; impulse response of systems; transfer function, the frequency response of first and second-order linear time-invariant systems, convolution, correlation. Discrete-time systems - impulse response, frequency response, DFT, Z - transform; basics of IIR and FIR filters.

### **Unit III Analog and Digital Electronics**

applications of operational amplifiers - difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, buffer, filters and waveform generators. Number systems, Boolean algebra; combinational logic circuits - arithmetic circuits, comparators, Schmitt trigger, encoder/decoder, MUX/DEMUX, multi-vibrators; Principles of ADC and DAC; Microprocessor- architecture, interfacing memory and input- output devices.

### **Unit IV Sensor and Biomedical Instrumentation**

Sensors - resistive, capacitive, inductive, piezoelectric, Hall effect, electro-chemical, optical; Sensor signal conditioning circuits; application of LASER in sensing and therapy. Principles of measuring blood pressure, body temperature, volume, and flow in arteries, veins and tissues, respiratory measurements and cardiac output measurement. Origin of biopotentials and their measurement techniques- ECG, EEG, EMG, ERG, EOG, GSR, PCG, Operating principle of medical equipment -sphygmomanometer, ventilator, cardiac pacemaker, defibrillator, pulse oximeter, hemodialyzer; Electrical Isolation (optical and electrical) and Safety of Biomedical Instruments.

## **Unit V Basic MATLAB**

Basic commands Assigning variables, Character and string Arrays and vectors, BODMAS Rules  
Arithmetic operations Operators and special characters, Finding transpose, determinant and inverse  
Solving matrix, Real numbers Complex numbers, Basic Plotting Functions

### **Reference:**

1. Anne Waugh and Allison Grant, Ross and Wilson “Anatomy and Human Physiology in Health and Illness” Ninth edition.
2. D. Roy Chowdary, Sheil B Jani- Linear Integrated circuits- new age publication, 2003 edition
3. Douglas K.Lindner, “Signals and Systems”, McGraw-Hill International, 1999.
4. Khandpur R.S, “Handbook of Biomedical Instrumentation”, Tata McGraw-Hill, New Delhi, 2003
5. Kattan, Peter I, “Matlab for Beginners: A gentle approach”, Petra books, 2008.

## **8. MANAGEMENT**

### **MODULE 1: HUMAN RESOURCE MANAGEMENT**

Concepts and perspectives in HRM; HRM in changing environment- Human Resource Planning – Objectives, Process and Techniques, Job analysis – Job Description, Selecting Human Resources- Induction, Training and Development. Exit policy and Implications- Performance Appraisal and Evaluation, Potential Assessment, Job Evaluation, Wage Determination, Industrial Relations and Trade Unions, Dispute Resolution-Grievance Management, Labour Welfare and Social Security Measures. Understanding and Managing individual behaviour personality- Perception – Values – Attitudes – Learning – Motivation-Communication – Leadership – Managing change – Managing conflicts, Organizational Development.

### **MODULE 2: MARKETING MANAGEMENT**

Marketing Environment and Environment Scanning; Marketing Information Systems and Marketing Research-Understanding Consumer and Industrial Markets; Demand Measurement and Forecasting- Market Segmentation – Targeting and Positioning; Product Decisions, Product mix, Product Life Cycle; New Product Development. Branding and Packaging; Pricing Methods and Strategies. Promotion Decisions – Promotion mix; Advertising; Personal Selling; Channel Management; Vertical Marketing Systems. Evaluation and Control of Marketing Effort; Marketing of Services; Customer Relation Management; Uses of Internet as a Marketing Medium – Other related issues like branding, market development, Advertising and retailing on the net. New issues in Marketing.

### **MODULE 3: PRODUCTION MANAGEMENT**

Role and Scope of Production Management; Facility Location; Layout Planning and Analysis; Production Planning and Control – Production Process Analysis; Demand Forecasting for Operations; Determinants of Product mix; Production Scheduling; Work measurement; Time and Motion Study; Statistical Quality Control-Role and Scope of Operations Research; Linear Programming; Sensitivity Analysis; Duality; Transportation Model; Inventory Control; Queuing Theory; Decision Theory; Markov Analysis; PERT /CPM. Basic Concept of Total Quality Management, Principles of total quality management, Objectives. Models and Process. Quality Management Philosophies, Tools for

Management Process, Strategic Planning and sustaining total quality. Benchmarking, Six Sigma and Business Process Re-engineering.

#### **MODULE 4 : QUANTITATIVE METHODS & TECHNIQUES**

Overview of Statistics, Classifying Data to convey meaning. Measures of Central Tendency –Mean, Median & Mode, Measures of Variation – Range, Average Deviation, Standard Deviation, Probability Theory. Probability distributions – Binomial, Poisson, Normal and Exponential; Correlation and Regression analysis; Sampling theory; Sampling distributions. Tests of Hypothesis; Large and small samples; t z, F, Chi – square tests. Use of Computers in Managerial applications; Technology issues and Data processing in Organizations; Information systems; MIS and Decision making; System analysis and design; Trends in Information Technology; Internet and Internet – based applications.

#### **MODULE5 : STRATEGIC MANAGEMENT**

Concept of Corporate Strategy; Components of Strategy Formulation. BCG Model; Porter’s Generic Strategies; Competitor Analysis; Strategic Dimensions and Group Mapping; Industry Analysis; Strategies in Industry Evolution, Fragmentation, Maturity, and decline. Competitive strategy and Corporate Strategy; Trans nationalization of World Economy. Managing Cultural Diversity; Global Entry Strategies; Globalization of Financial System and Services; Managing International Business; Competitive Advantage of Nations; RTP and WTO. Corporate governance, theories of corporate governance, composition of board, procedures and principles of good governance, governance reforms in India.

**Ph.D. in Law Admission Test- Syllabus**

**CONTEMPORARY DEVELOPMENTS  
IN THE FIELD OF LAW & SOCIETY**

**UNIT-I: Constitutional Law Of India:** Preamble-Fundamental Rights and Duties-Directive Principles of State Policy-Judiciary-Executive- Union State Legislative Relations-Emergency Provisions-Amendment of the Constitution-Writ Jurisdiction.

**UNIT-II: Legal Theory:** Nature and Sources of Law-Schools of Law - Positivism, Natural Law Theory and Sociological Jurisprudence-Theories of Punishment- Concepts of Person, Property, Rights and Duties, Possession and Ownership.

**UNIT-III: Public International Law:** Nature of International Law and its Relationship with Municipal Law-Recognition of States and Governments-United Nations-Settlement of International Disputes- Human Rights.

**UNIT-IV: Law of Contracts and Family Law:** a) Essentials of a valid Contract- Offer, acceptance and consideration- Capacity to Contract- Minor's Contract-Elements Vitiating Contracts- Mistake, Fraud, Misrepresentation, Public Policy, Coercion, Undue Influence, Frustration of Contract-Remedies for Breach of Contract- Damages. a) Concepts in Family Law-Sources of Family Law in India-Marriage and Dissolution of Marriage. Matrimonial Remedies-Maintenance-Customary Practices and the Law.

**UNIT-V: Law of Torts and Crimes:** a) Foundation of Tortious Liability-General Defences to an act of Tort- Vicarious Liability- Remoteness of Damages- Contributory Negligence- Absolute and Strict Liability. b) Nature and Definition of Offence- General Exceptions-Common Intention and Common Object-Criminal Attempt, Conspiracy and Abetment- Offences against Women.

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*A. Subramanyam*

Prof. A. Subramanyam  
Dean School of Law

**Vel Tech**

Rangarajan Dr. Srinivasulu  
MD Bangalore 560029  
Established in 1988

### Section 1: Physical Chemistry

**Structure:** Postulates of quantum mechanics. Time dependent and time independent Schrödinger equations. Born interpretation. Particle in a box. Harmonic oscillator. Rigid rotor. Hydrogen atom; atomic orbitals. Multi-electron atoms: orbital approximation. Variation and first order perturbation techniques. Chemical bonding: Valence bond theory and LCAO-MO theory. Hybrid orbitals. Applications of LCAO-MO to  $H_2^+$ ,  $H_2$  and other homonuclear diatomic molecules, heteronuclear diatomic molecules like HF, CO, NO, and to simple delocalized  $\pi$ -electron systems. Hückel approximation and its application to annular  $\pi$ -electron systems. Symmetry elements and operations. Point groups and character tables. Origin of selection rules for rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Einstein coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength. Basic principles of nuclear magnetic resonance: nuclear  $g$  factor, chemical shift, nuclear coupling.

**Equilibrium:** Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, van't Hoff equation. Criteria of spontaneity and equilibrium. Absolute entropy. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Chemical equilibria. Dependence of equilibrium constant on temperature and pressure. Non-ideal solutions, ionic mobility and conductivity. Debye-Hückel limiting law. Debye-Hückel-Onsager equation. Standard electrode potentials and electrochemical cells. Potentiometric and conductometric titrations. Phase rule. Clausius-Clapeyron equation. Phase diagram of one component systems:  $CO_2$ ,  $H_2O$ , S; two component systems: liquid-vapour, liquid-liquid and solid-liquid systems. Fractional distillation. Azeotropes and eutectics. Statistical thermodynamics: microcanonical and canonical ensembles, Boltzmann distribution, partition functions and thermodynamic properties.

**Kinetics:** Transition state theory: Eyring equation, thermodynamic aspects. Potential energy surfaces and classical trajectories. Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Mechanisms of complex reactions. Unimolecular reactions. Kinetics of polymerization and enzyme catalysis. Fast reaction kinetics: relaxation and flow methods. Kinetics of photochemical and photophysical processes.

**Surfaces and Interfaces:** Physisorption and chemisorption. Langmuir, Freundlich and BET isotherms. Surface catalysis: Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Physical chemistry of colloids, micelles and macromolecules.

### Section 2: Inorganic Chemistry

**Main Group Elements:** Hydrides, halides, oxides, oxoacids, nitrides, sulfides – shapes and reactivity. Structure and bonding of boranes, carboranes, silicones, silicates, boron nitride, borazines and phosphazenes. Allotropes of carbon. Chemistry of noble gases, pseudohalogens, and interhalogen compounds. Acid-base concepts.

**Transition Elements:** Coordination chemistry – structure and isomerism, theories of bonding (VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn-Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel diagrams, charge-transfer spectra. Magnetic



properties of transition metal complexes. Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions.

**Lanthanides and Actinides:** Recovery, Periodic properties, spectra and magnetic properties.

**Organometallics:** 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal-carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis and olefin oxidation. Heterogeneous catalysis - Fischer-Tropsch reaction, Ziegler-Natta polymerization.

**Radioactivity:** Decay processes, half-life of radioactive elements, fission and fusion processes.

**Bioinorganic Chemistry:** Ion ( $\text{Na}^+$  and  $\text{K}^+$ ) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper and zinc.

**Solids:** Crystal systems and lattices, Miller planes, crystal packing, crystal defects, Bragg's law, ionic crystals, structures of AX, AX<sub>2</sub>, ABX<sub>3</sub> type compounds, spinels, band theory, metals and semiconductors.

**Instrumental Methods of Analysis:** UV-visible spectrophotometry, NMR and ESR spectroscopy, mass spectrometry. Chromatography including GC and HPLC. Electroanalytical methods- polarography, cyclic voltammetry, ion-selective electrodes. Thermoanalytical methods.

### Section 3: Organic Chemistry

**Stereochemistry:** Chirality of organic molecules with or without chiral centres and determination of their absolute configurations. Relative stereochemistry in compounds having more than one stereogenic centre. Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Stereoselective and stereospecific synthesis. Conformational analysis of acyclic and cyclic compounds. Geometrical isomerism. Configurational and conformational effects, and neighbouring group participation on reactivity and selectivity/specificity.

**Reaction Mechanisms:** Basic mechanistic concepts - kinetic versus thermodynamic control, Hammond's postulate and Curtin-Hammett principle. Methods of determining reaction mechanisms through identification of products, intermediates and isotopic labeling. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Addition reactions to carbon-carbon and carbon-heteroatom (N,O) multiple bonds. Elimination reactions. Reactive intermediates - carbocations, carbanions, carbenes, nitrenes, arynes and free radicals. Molecular rearrangements involving electron deficient atoms.

**Organic Synthesis:** Synthesis, reactions, mechanisms and selectivity involving the following classes of compounds - alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Uses of Mg, Li, Cu, B, Zn and Si based reagents in organic synthesis. Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille and Sonogoshira. Concepts of multistep

synthesis - retrosynthetic analysis, strategic disconnections, synthons and synthetic equivalents. Umpolung reactivity - formyl and acyl anion equivalents. Selectivity in organic synthesis - chemo-, regio- and stereoselectivity. Protection and deprotection of functional groups. Concepts of asymmetric synthesis - resolution (including enzymatic), desymmetrization and use of chiral auxiliaries. Carbon-carbon bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Michael addition reaction. Stereoselective addition to C=O groups (Cram and Felkin-Anh models).

**Pericyclic Reactions and Photochemistry:** Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlations - FMO and PMO treatments. Photochemistry of alkenes, arenes and carbonyl compounds. Photooxidation and photoreduction. Di- $\pi$ -methane rearrangement, Barton reaction.

**Heterocyclic Compounds:** Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

**Biomolecules:** Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, structural features of proteins, nucleic acids, steroids, terpenoids, carotenoids, and alkaloids.

**Spectroscopy:** Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.



## **11. ENGLISH**

1. Chaucer to Shakespeare
2. Romantic Period
3. Victorian Period
4. Modern Period
5. Contemporary Period
6. History of English Language
7. English Language Teaching
8. Indian Writing in English
9. Indian Literature in English Translation
10. Contemporary British literature
11. Modern British Literature
12. American and other non-British English Literature
13. Contemporary Theory
14. Literary Theory and Criticism

## 12. MATHEMATICS

**Linear Algebra:** Finite dimensional vector spaces; Linear transformations and their matrix representations, rank; systems of linear equations, eigen values and eigen vectors, minimal polynomial, Cayley-Hamilton Theorem, diagonalisation, Hermitian, Skew-Hermitian and unitary matrices; Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, self-adjoint operators.

**Complex Analysis:** Analytic functions, conformal mappings, bilinear transformations; complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle; Taylor and Laurent's series; residue theorem and applications for evaluating real integrals.

**Real Analysis:** Sequences and series of functions, uniform convergence, power series, Fourier series, functions of several variables, maxima, minima; Riemann integration, multiple integrals, line, surface and volume integrals, theorems of Green, Stokes and Gauss; metric spaces, completeness, Weierstrass approximation theorem, compactness; Lebesgue measure, measurable functions; Lebesgue integral, Fatou's lemma, dominated convergence theorem.

**Ordinary Differential Equations:** First order ordinary differential equations, existence and uniqueness theorems, systems of linear first order ordinary differential equations, linear ordinary differential equations of higher order with constant coefficients; linear second order ordinary differential equations with variable coefficients; method of Laplace transforms for solving ordinary differential equations, series solutions; Legendre and Bessel functions and their orthogonality.

**Algebra:** Normal subgroups and homomorphism theorems, automorphisms; Group actions, Sylow's theorems and their applications; Euclidean domains, Principal ideal domains and unique factorization domains. Prime ideals and maximal ideals in commutative rings; Fields, finite fields.

**Functional Analysis:** Banach spaces, Hahn-Banach extension theorem, open mapping and closed graph theorems, principle of uniform boundedness; Hilbert spaces, orthonormal bases, Riesz representation theorem, bounded linear operators.

**Numerical Analysis:** Numerical solution of algebraic and transcendental equations: bisection, secant method, Newton-Raphson method, fixed point iteration; interpolation: error of polynomial interpolation, Lagrange, Newton interpolations; numerical differentiation; numerical integration: Trapezoidal and Simpson rules, Gauss Legendre quadrature, method of undetermined parameters; least square polynomial approximation; numerical solution of systems of linear equations: direct methods (Gauss elimination, LU decomposition); iterative methods (Jacobi and Gauss-Seidel); matrix eigenvalue problems: power

method, numerical solution of ordinary differential equations: initial value problems: Taylor series methods, Euler's method, Runge-Kutta methods.

**Partial Differential Equations:** Linear and quasilinear first order partial differential equations, method of characteristics; second order linear equations in two variables and their classification; Cauchy, Dirichlet and Neumann problems; solutions of Laplace, wave and diffusion equations in two variables; Fourier series and Fourier transform and Laplace transform methods of solutions for the above equations.

**Mechanics:** Virtual work, Lagrange's equations for holonomic systems, Hamiltonian equations.

**Topology:** Basic concepts of topology, product topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

**Probability and Statistics:** Probability space, conditional probability, Bayes theorem, independence, Random variables, joint and conditional distributions, standard probability distributions and their properties, expectation, conditional expectation, moments; Weak and strong law of large numbers, central limit theorem; Sampling distributions, UMVU estimators, maximum likelihood estimators, Testing of hypotheses, standard parametric tests based on normal,  $X^2$ ,  $t$ ,  $F$  – distributions; Linear regression; Interval estimation.

**Linear programming:** Linear programming problem and its formulation, convex sets and their properties, graphical method, basic feasible solution, simplex method, big-M and two phase methods; infeasible and unbounded LPP's, alternate optima; Dual problem and duality theorems, dual simplex method and its application in post optimality analysis; Balanced and unbalanced transportation problems, u -u method for solving transportation problems; Hungarian method for solving assignment problems.

**Calculus of Variation and Integral Equations:** Variation problems with fixed boundaries; sufficient conditions for extremum, linear integral equations of Fredholm and Volterra type, their iterative solutions.

## 13. PHYSICS

### Classical Mechanics

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics- moment of inertia tensor. Non-inertial frames and pseudoforces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity- Lorentz transformations, relativistic kinematics and mass-energy equivalence. Dynamical systems, Phase space dynamics, stability analysis. Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory.

### Quantum Mechanics

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wavefunction in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time- independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli Exclusion Principle, spin- statistics connection. Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein- Gordon and Dirac equations. Semi-classical theory of radiation.

### Atomic & Molecular Physics

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrumlines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A& B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

### Condensed Matter Physics

Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response

and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

### **Nuclear and Particle Physics**

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

### **Thermodynamic and Statistical Physics**

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law